Justin Morgenroth of The University of Canterbury operates the Air Spade to expose roots.

THE ROOT OF THE PROBLEM

Andrew Benson, Ph.D. & Justin Morgenroth, Ph.D.

Introduction

The CODIT model with which we are all familiar (Shigo, 1984) has helped to inform arboricultural experts and practitioners of the correct way in which a tree branch should be removed to achieve the optimal biological response, e.g., to limit decay and optimise compartmentalisation / occlusion. More recently, some investigators have examined how the diameter of branch pruning cuts relative to the parent trunk diameter can affect post-pruning decay (Gilman & Grabosky, 2006) or epicormic shoot response (Perrette et al., 2021). Larger wounds typically produce more decay and more epicormic shoots. Furthermore, internodal branch pruning which leaves short stubs inherently produces epicormic shoots (Attocchi, 2013) and sub-optimises the compartmentalisation process (Sheppard et al., 2016). Research has also shown that the compartmentalisation response of wounded trees is optimised when wounds are inflicted during periods of active growth, as opposed to periods of dormancy (Dujesiefken et al., 2005).

Much attention has been given to how the accessible, aboveground tree structures respond to injury, yet little attention has been paid to how the roots of trees individually respond to root pruning. This is largely because root pruning research is a messy business and usually involves getting quite dirty for days at a time. To date, root pruning research has largely focused on the wider effects of cumulative root loss on tree health (e.g. Dong et al., 2016, Benson et al., 2019b, Benson et al., 2019c, Fini et al., 2020), growth (e.g. Watson, 1998, Pretzsch et al., 2016) or stability (e.g. Smiley, 2008, Smiley et al., 2014), which has helped to inform current best practice as this relates to protecting trees in the urban environment (British Standards Institute, 2012, Fite & Smiley, 2016, Costello et al., 2017, Benson et al., 2019a).

Root pruning is an injurious practice wherein a tree may have one or more of its roots severed and removed (Hagen, 2001). In the urban environment, the roots of trees are often removed to alleviate conflicts with the surrounding infrastructure such as footpaths (Wong et al., 1988, Nicoll & Armstrong, 1998, Reichwein, 2002, Kadir & Othman, 2012), or buried utilities (Mattheck & Breloer, 2007, Watson et al., 2014). Mature trees with well-developed root systems are more likely to damage hard surfaces and are therefore more at risk of root loss during footpath repair operations (Kopinga, 1994, Nicoll & Armstrong, 1998). It is desirable for us to understand how roots respond to different pruning techniques and at different times, to optimise the biological response of trees to this type of injury.

Getting our hands dirty

To begin answering some of these questions, I headed off to Christchurch in October last year to meet Justin Morgenroth at the New Zealand School of Forestry, to get our hands dirty for a few days. Toby Chapman at Christchurch City Council kindly found us an avenue of mature Platanus to work with in Hagley Park and we set about digging some holes. Using half of the trees, we made a single trench about three times DBH from the base of each tree using an AirSpade until we found three suitable roots. Once we'd found three roots, we pruned them in one of two ways. Either we cut the root as we found it, leaving a 100 mm 'stub' (a bit like a topping cut), or we used the AirSpade to trace its outward growth until we found a 'fork', and then made a reduction cut, leaving a subordinate lateral root. We recorded the sizes and positions of the roots and took some photographs before backfilling the trenches with native soil and sprinkling some grass seed – you'd never know we were there. I went back to Christchurch again in April of this year and repeated this on the second half of the trees, so that we can compare the way they respond to having their roots cut during an active growth season to this being done in a period of dormancy.

Left: Pruned roots are labelled and photographed before being buried.

Right: How many scientists does it take to find a root? The buried root records are double-checked before the investigators leave for the day.

Root responses

Now because trees don't always respond quite as quickly as we'd like them to when we do research, we'll need to wait a while before we can get the data. Each tree will be given two years to respond to the root cutting, which should be enough time to see the early signs of decay, and we should see some new root growth as well. So, in October 2022 and April 2023, we'll be digging up the roots again and taking some samples back to the university's laboratory. The things we're looking for are new root growth and the area of decay, or dysfunction. We can express this in terms which are relative to the size of the root cut so we get a consistent set of data. We'll quantify the new root growth in terms of dry weight, which just means we'll cut away all the new fine roots, dry them in an oven overnight and then weigh them. Then, the pieces of root we'll remove will be cut longitudinally and the area of discolouration (a symptom of root decay) measured using image processing tools. We'll report back on all these results in a couple of years, so watch this space until then.

The results of this study will help us to understand how the timing and location of root pruning impacts biological response. It's the next step in improving our understanding of how roots respond to injury. In doing so, it will help us inform root pruning best practice.

The authors wish to express their gratitude to NZ Arb for providing financial assistance towards the project, and also to Toby Chapman who provided trees, a vehicle, equipment and a friendly smile. Thanks also to Jihwi Jang for his field assistance in October. Thanks NZ Arb, Toby, and Jihwi :)

Severed roots off to the laboratory for analysis.

References

Attocchi G, 2013. Effects of pruning and stand density on the productionof new epicormic shoots in young stands of pedunculate oak (Quercus robur L.). ***Annals of Forest Science* 70**, 663-73.

Benson A, Koeser A, Morgenroth J, 2019a. A test of tree protection zones: Responses of live oak (Quercus virginiana Mill) trees to root severance treatments. ***Urban Forestry & Urban Greening* 38**, 54-63.

Benson A, Morgenroth J, Koeser A, 2019b. The effects of root pruning on growth and physiology of two Acer species in New Zealand. ***Urban Forestry & Urban Greening* 38,** 64-73.

Benson A, Morgenroth J, Koeser A, 2019c. Responses of mature roadside trees to root severance treatments. ***Urban Forestry & Urban Greening* 46**.

British Standards Institute, 2012. BS5837:Trees in Relation to Design, Demolition and Construction-Recommendations. In. United Kingdom: BSI Standards Limited.

Costello LR, Watson G, Smiley ET, 2017. ***Best Management Practices: Root management*** Champaign, Illinois, USA: International Society of Arboriculture.

Dong T, Duan B, Zhang S, Korpelainen H, Niinemets U, Li C, 2016. Growth, biomass allocation and photosynthetic responses are related to intensity of root severance and soil moisture conditions in the plantation tree ***Cunninghamia lanceolata. Tree Physiology* 36**, 807-17.

Dujesiefken D, Liese W, Shortle W, Minocha R, 2005. Response of beech and oaks to wounds made at different times of the year. ***European Journal of Forest Research* 124**, 113-7.

Fini A, Frangi P, Mori J, Sani L, Vigevani I, Ferrini F, 2020. Evaluating the effects of trenching on growth, physiology and uprooting resistance of two urban tree species over 51-months. ***Urban Forestry & Urban Greening***, 126734.

Fite K, Smiley ET, 2016. ***Best Management Practices (BMP) - Managing Trees During Construction***. Champaign, Illinois, USA: International Society of Arboriculture.

Gilman EF, Grabosky JC, 2006. Branch Union Morphology Affects Decay Following Pruning. ***Arboriculture & Urban Forestry* 32**, 74.

Hagen B, 2001. Back to Basics: Tree Roots. ***The Western Arborist* 26**, 11-4.

Kadir MaA, Othman N, 2012. Towards a Better Tomorrow: Street Trees and Their Values in Urban Areas. ***Procedia - Social and Behavioral Sciences* 35**, 267-74.

Kopinga J, 1994. Aspects of the damage to asphalt road pavings caused by tree roots. In: Watson GW, ed. ***The Landscape Below Ground I. Proceedings of an International Workshop on Tree Root Development in Urban Soils*** Champaign, Ill, USA.: International Society of Arboriculture, 165-78.

Mattheck C, Breloer H, 2007. Wind, Roots and Pipelines. In: Lonsdale D, ed. ***The body language of trees: A handbook for faiure analysis***. Norwich, UK: The Stationary office (TSO), 88-97. (4.)

Nicoll BC, Armstrong A, 1998. Development of Prunus root systems in a city street: Pavement damage and root architecture. ***Arboricultural Journal* 22**, 259-70.

Perrette G, Delagrange S, Ramirez JA, Messier C, 2021. Optimizing reduction pruning under electrical lines: The influence of tree vitality before pruning on traumatic responses. ***Urban Forestry & Urban Greening* 63**, 127139.

Pretzsch H, Bauerle T, Häberle KH, Matyssek R, Schütze G, Rötzer T, 2016. Tree diameter growth after root trenching in a mature mixed stand of Norway spruce (Picea abies [L.] Karst) and European beech (***Fagus sylvatica*** [L.]). ***Trees - Structure and Function* 30**, 1761-73.

Reichwein S, 2002. ***Baumwurzeln unter Verkehrsflächen - Untersuchungen zu Schäden an Verkehrsflächen durch Baumwurzeln und Ansätze zur Schadensbehebung und Schadensvermeidung. Beiträge zur räumlichen Planung. [Tree roots under traffic areas - Investigations on damage to traffic areas by tree roots and approaches to damage repair and damage prevention. Contributions to spatial planning.]***. Hanover, Germany: University of Hanover, Germany, Ph.D. Doctoral dissertation.

Sheppard J, Urmes M, Morhart C, Spiecker H, 2016. Factors affecting branch wound occlusion and associated decay following pruning – a case study with wild cherry (Prunus avium L.). ***Annals of Silvicultural Research* 40**, 133-9.

Shigo AL, 1984. Compartmentalization: a conceptual framework for understanding how trees grow and defend themselves. ***Annual Review of Phytopathology* 22**, 189-214.

Smiley ET, 2008. Root pruning and stability of young willow oak. ***Arboriculture and Urban Forestry* 34**, 123-8.

Smiley ET, Holmes L, Fraedrich BR, 2014. Pruning of buttress roots and stability changes of red maple (***Acer rubrum***). ***Arboriculture and Urban Forestry* 40**, 230-6.

Watson GW, 1998. Tree growth after trenching and compensatory crown pruning. ***Journal of Arboriculture* 24**, 47-53.

Watson GW, Hewitt AM, Custic M, Lo M, 2014. The management of tree root systems in urban and suburban settings II: A review of strategies to mitigate human impacts. ***Arboriculture and Urban Forestry* 40**, 249-71.

Wong TW, Good JEG, Denne MP, 1988. Tree root damage to pavements and kerbs in the city of Manchester. ***Arboricultural Journal* 12**, 17-34.